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# FOCEX–A Fiber-Optic Cable Extender for a High Speed Parallel RS485 Data Cable

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## Disclaimer

# FOCEX - a Fiber-Optic Cable EXtender for a High Speed Parallel RS485 Data Cable

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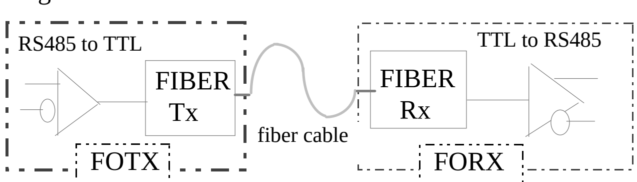
*Abstract*

*There seems to be an echo in the Data Movers Community.* "For longer-distance, high speed data links, optical fibre becomes more cost-effective than copper cable" or other hard wire cable systems. A portion of the previous statement is quotable from many oral and written sources.

Fermilab[1] supplied to Finisar Corp. of Menlo Park, CA., a set of specifications for card functions, sizes and interconnector pin assignments. Finisar designed and assembled a set of fiber optical P.C. cards using 100 megabyte/sec commercial optoelectronics and a serialization and deserialization HOT-ROD chipset designed by GAZELLE Microcircuits, Inc. (A Tri _Quint Semiconductors company).

The cooperative effort between Fermilab and Finisar has allowed Fermilab to created a reliable 50 Megabytes/sec (40 bit parallel RS485 DART[2] data bus) cable to cable extender using a virtually invisible Fiber Channel point-to-point (FC-0) fiber optical single-simplex system. The system is easily capable of sustaining a 50 megabytes/sec of data, control and status lines throughput at distances of 1625 feet (500 meters) using standard multi-mode fiber.




1 Fermilab is operated by Universities Research Association Inc. under Contract No. DE-AC02-76CHO3000 with the United States Department of Energy.

2 DART = Fermilab Data Acquisition Real Time. A Fermilab Computing Division high speed transport bus using a 40 bit parallel IEEE EIA-RS485 Differential TTL cable clocked at 10MHZ (max speed of RS485@approx. 25 meters) =50 megabytes per second (32 data bits and 8 control and/or status bits).

## I. INTRODUCTION

High energy physics detectors now produce more data, at faster rates than ever before. The time has come when the front end circuits that produce the data can no longer evaluate the absolute value of what is good and what is important. The assembly of raw data events is being done in local smart crates using the power of the local or on-board computer only to gather and send the data out of the detector areas on high speed data interfaces. The long distances, limited access areas and the required higher speeds now demand that more reliable long distance electronic data link systems be built to transport the data to remote collection points.

The construction, assembly and installation of 11 complete Fiber Cable Extender sets (FOCEXs), which included one (1) set for return status, was requested by Fermilab experiment E781 (SELEX: SEgmented Large-x baryon spectrometer EXperiment). The eleventh FOCEX set is being used to return status's and/or flow control bits to the originating sources from the multiple remote receiving destinations.

The links are designed to handle the isolation and long distance problems existing over the output data bus cables between the event building front end data acquisition hardware and the data stream destinations located in a set of PORTAKAMPS approximately 110 meters or 425 feet away. The data source hardware is located in a below ground pit area very near sources of high levels of electromagnet, magnetic, RF and capacitive signal noise. These effects can be introduced to the data bus equipment and cables.

The FOCEX module sets allow the experiment's needed RS485 data cabling lengths/per stream to be minimized to less than 20-25 feet. The shortness of the cable and the use of the NIM crates and the NIM FARADAY shielded design form factor for powering and shielding the fiber extender units lowers the susceptibility to stray induced noises.

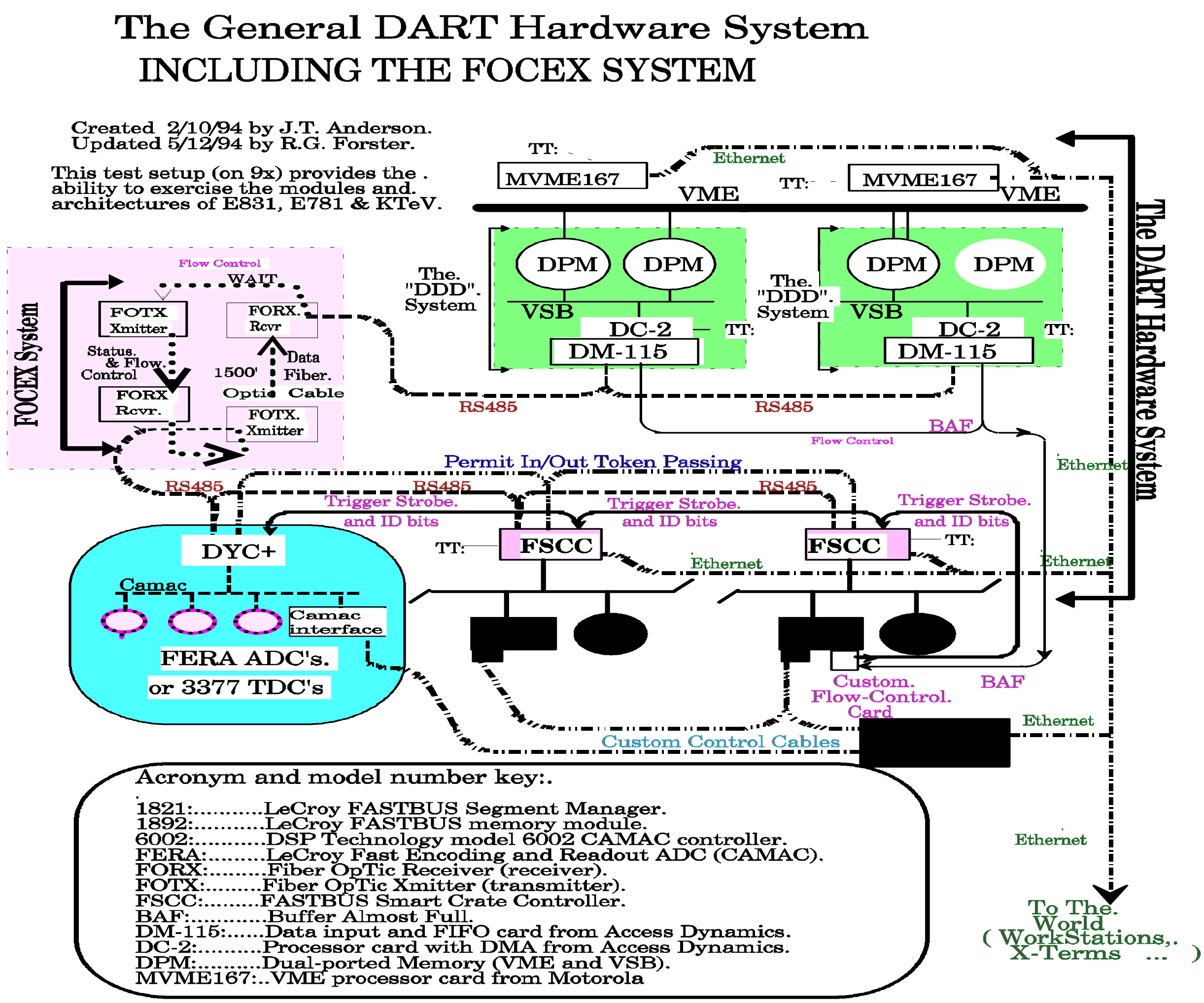



Figure 1: Fiber Optic Cable EXtender in the data stream flow

## II. SYSTEM COMPONENTS

There are 8 subsystems contained in the FOCEX system.

- The RS485 DART[2] DATA (parallel to TTL) converter and fiber transmitter control card (DAH009). Called the FOTX motherboard.

- The fiber receiver (TTL to RS485) DART[2] DATA bus driver control card (DAH010). Called the FORX motherboard .

- The FTC-1000 and FRC-1000 Finisar fiber link transmitter and receiver daughter cards which are mounted on their respective motherboards. The rear DIN connectors pin outs are VME standards J2/P2 compatible and can be aligned to plug into the VME J2/P2 connectors of a U6 or U9 VME crate.

- A 40 bit parallel , 100 megabit/sec to 1 Gbit/sec, TTL compatible input/output, point to point data communication chipset.
  HOTROD Tx( GA9011-8x encoder/ serializer)
  HOTROD Rx( GA9012-8x deserializer/ decoder)

- A single set of FOTX and FORX modules configured to return selected control and/or flow control signals from several of the downstream destination devices to their respective upstream sources.

The FOTX transmit module is made up of a Finisar FTC-1000 card mated to a FERMILAB RS485 to TTL fiber transmitter interface control card (DAH009PC).

The FORX receiver module is made up of a Finisar FRC-1000 card mated to a FERMILAB fiber receiver TTL to RS485 interface control card (DAH010PC).

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[2] DART = See footnote #2 on the first page

## III. SERIALIZATION

The FOTX asynchronously receives 40 bits of parallel RS485 input cable data and control signals at up to a 10MHZ (50mbytes/sec) rate, included in the 40 bits is an appropriate data strobe level. The latched data and control lines are encrypted (FDDI 4bit/5bit encryption formula) and serially sent over the fiber cable to the remotely located FORX receiver unit.

The FORX deserializes the encrypted 50 bit word packet and latches the decoded (FDDI 5bit/4bit) word into a 41 bit 4k word deep storage FIFO (one bit/word is a parity/error flag bit.). The data is flushed out of the receiver's FIFO buffer into the interface control card's output driver latches where a detected and appropriately timed data strobe pulse is regenerated. By design, the FORX module is limited to a sustained 52.50 megabytes/sec flush rate. The slightly faster FORX clock rate assures that the Tx and Rx controllers will not overrun or underrun each other.

## IV. CONTROL LINES

Control line 'transitional changes of state' recognition are designed into the FORX and FOTX PAL programs. A fiber word is transmitted for each control line transitional change of state detected. The DART RS485 control lines can change states but must do so at an appropriate time outside of the data window time period. There are NO accompanying FORX 'DART data cable strobes' generated for any received 'change of state' of any control line. Reactions to the control line state changes are left up to the destination devices.

## V. SYSTEM RELIABILITY

The GAZELLE HOT ROD chipsets used on the FTC-1000 and the FRC-1000 modules have been tested for long term stability by Finisar Corp. The fiber link and control circuits were designed around the ASYNCHRONOUS capability feature of the HOT ROD chipset design. The use of the ASYNCHRONOUS data transfer mode eliminates the need for any synchronous controls signals and allows the input strobe rate to be run at any rate slower than 90 Megabytes/second (17-18 MHZ).

The SYNCHRONOUS hand shaking feature would have been a hard feature to control and would have required some retrofitting to the various asynchronous DART data input sources.

Since the experiment's RS485 input rate is asynchronously applied at 10 MHZ the auto-insertion of fiber sychronization frames between data words frames is a constant stability feature and not a problem.

The separate FOTX and FORX interface modules remove the redundancy and under utilization of the returning fiber status circuits required for full twin-simplex configurations, is much more cost effective, and reduces the need for extra and costly return fibers and components.

The FLOW CONTROL RETURN CIRCUIT (WAIT, etc.) utilizes the RAW MODE feature of the FOCEX modules (see section VII: A Second MODE).

By selecting a NIM module form factor for the interface chassis and the low current drain of the driver and receiver chips, a relatively cheap and readily available power source and crate system can be used. For heavily loaded NIM crates an ancillary MOLEX power connector is located on the rear of the module. Both rear panel power connectors are individually fused and diode protected.

## VI. THE SYSTEM IS RUNNING

As of this date the FOCEX system is running at E781 with 6 of the expected 10 streams having been tested at an average 20-30 megabytes/sec throughput with the data cable block burst speed of 50 megabytes/sec.

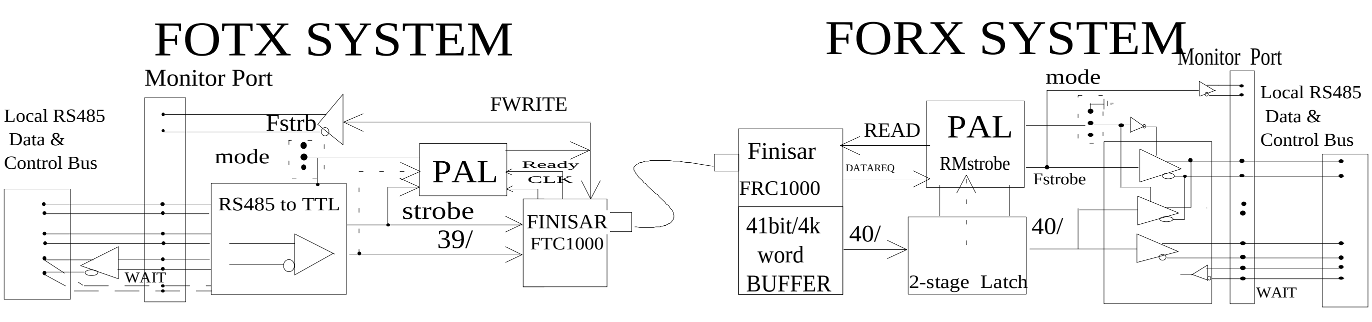


Figure #2: Block functional diagram of FOTX and FORX including Finisar FTC-1000 and FRC-1000.

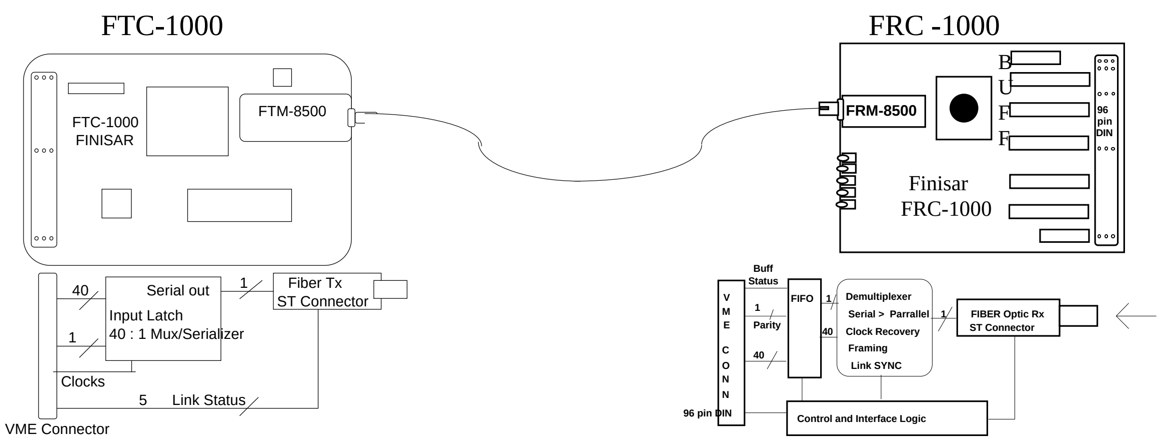


FIGURE #3: Block diagram of the FTC-1000 and the FRC-1000 daughter cards.

## VII. EXTENDED SPECIFICATIONS OF THE INDIVIDUAL PARTS

### FOTX(with Finisar card)

INPUT rate can be 90 Megabytes/sec of RS485 data Asynchronously applied and 100 Megabytes/sec of RS485 Synchronously applied.( 40 bits of parallel RS485 lines)
Single NIM module design form factor.
Power + 6 Volts from a rear NIM connector or from a rear panel ancillary Molex connector.
Front panel has 2 DART RS485 cable connectors and a 20 pin Monitor port connector to facilitate external access to the RS485 cable signals

A Second MODE

RAW MODE : Runs in a 40 bit Sample mode at a preprogrammed selected rate.

FTC-1000/FTM-8500-8510 Fiber optic data link driver

40 bits TTL - 90 Megabytes Asynchronously
100 Megabytes/sec Synchronously
Can drive at a wavelength of 850 nanometers on 500 meters of fiber wire using 62.5/125 or 50/125 multi-mode fiber with ST style connector.
Power +5 Volts from 96 Pin DIN connector ROWb.

### FORX(with Finisar RX card)

OUTPUT data rates is a 40 bit RS485, 50-52.5 Megabytes/sec flush rate as controlled by the FORX crystal and PAL selected.

Single NIM module design form factor.
Power +6 Volts from rear NIM connector or from a rear panel ancillary Molex connector.
Front panel has 2 DART RS485 cable connectors and a 20 pin Monitor port connector to facilitate external access to the RS485 cable signals

A Second MODE

RAW MODE asserts a received 40 bit word onto RS485 data lines but does not assert a strobe pulse. A form of a strobe can be obtained from a set of the Port Monitor pins.

FRC-1000/FRM-8500-8510 Fiber optic data line receiver

40 bit TTL - 90 Megabytes Asynchronously and
100 Megabytes/sec Synchronously.
Can receive at a wavelength of 850 nanometers on fiber wire using 62.5/125 or 50/125 multi-mode fiber with ST style connector.
Power +5 Volts from 96 Pin DIN connector ROWb.

## ACKNOWLEDGMENT

We wish to thank Fermilab and E781 (SELEX) both for demonstrating their confidence in us by posing their problem to us, and for accepting our solution.

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